

CLAIMS

1 1. A method for performing coverability analysis
2 in software, comprising:
3 performing a static analysis of software under test
4 (SUT) so as to identify a plurality of dominating blocks
5 in the SUT;

6 formulating respective coverability tasks for the
7 dominating blocks of the SUT;

8 generating rules regarding behavior of the SUT
9 corresponding respectively to the coverability tasks;

10 for each of the rules, running a symbolic model
11 checker to test a behavioral model of the SUT, so as to
12 produce respective results for the rules; and

13 computing a coverability metric for the SUT
14 responsive to the results and the coverability tasks.

1 2. A method according to claim 1, and comprising
2 writing the SUT in a programming language adapted to
3 define at least one of a group of elements comprising a
4 software element and a hardware element.

1 3. A method according to claim 1, wherein
2 performing the static analysis of the SUT comprises:

3 identifying a set of dominating blocks in the SUT;
4 and

5 solving a subset cover problem on the set of
6 dominating blocks so as to identify the plurality of
7 dominating blocks.

1 4. A method according to claim 3, wherein the set
2 of dominating blocks comprises a set of all dominating
3 blocks in the SUT, and wherein the plurality of
4 dominating blocks comprises fewer blocks than the set of
5 all dominating blocks in the SUT.

1 5. A method according to claim 4, wherein running

2 the symbolic model checker comprises performing a number
3 of executions of the symbolic model checker smaller than
4 a total number of all the dominating blocks in the SUT.

1 6. A method according to claim 1, wherein
2 formulating the respective coverability tasks for the
3 dominating blocks of the SUT comprises formulating
4 coverability tasks by at least one of a group of methods
5 comprising manual formulation and automatic formulation.

1 7. A method according to claim 1, wherein
2 generating the rules regarding behavior of the SUT
3 comprises generating rules by at least one of a group of
4 methods comprising manual generation and automatic
5 generation.

1 8. A method according to claim 1, wherein running
2 the symbolic model checker to test the behavioral model
3 of the SUT comprises:

4 evaluating the respective results so as to determine
5 the truth or falsity of the rule; and

6 generating a list of uncoverable elements responsive
7 to the respective results.

1 9. A method according to claim 1, wherein
2 generating the rules regarding behavior of the SUT
3 corresponding respectively to the coverability tasks
4 comprises instrumenting the SUT by adding one or more
5 statements and one or more auxiliary variables thereto,
6 so as to facilitate evaluation of the rules.

1 10. A method according to claim 9, wherein
2 instrumenting the SUT comprises:

3 determining a plurality of basic blocks comprised in
4 the SUT; and

5 for each basic block:

6 defining an auxiliary variable for the block;

7 initializing the auxiliary variable to zero; and

8 ' assigning the auxiliary variable a non-zero value
9 upon execution of the basic block.

1 11. A method according to claim 9, wherein
2 instrumenting the SUT comprises:

3 determining a plurality of basic blocks comprised in
4 the SUT;

5 defining a single auxiliary variable for the SUT;

6 initializing the single auxiliary variable to zero;

7 and

8 assigning a unique non-zero value to the single
9 auxiliary variable upon execution of each basic block.

1 12. A method according to claim 1, wherein
2 computing the coverability metric comprises:

3 evaluating an attained coverability responsive to
4 the respective results produced by running the symbolic
5 model checker;

6 evaluating an unattained coverability responsive to
7 the respective results produced by running the symbolic
8 model checker;

9 performing a comparison between the attained
10 coverability and the coverability tasks;

11 calculating the coverability metric responsive to
12 the comparison; and

13 analyzing the behavioral model of the SUT with
14 respect to the unattained coverability.

1 13. A method according to claim 1, and comprising
2 analyzing a design of the SUT, responsive to the
3 coverability metric, for at least one of a group of
4 properties comprising dead code, unattainable states,
5 uncoverable statements, uncoverable states, unattainable
6 transitions, unattainable variable values, and
7 unreachable conditions.

1 14. A method according to claim 1, and comprising

2 applying a testing strategy chosen from one of a group of
3 strategies comprising excluding uncoverable elements from
4 coverage measurements, setting coverage goals responsive
5 to the coverability metric, and determining a criterion
6 for stopping testing responsive to the coverability
7 metric.

1 15. A method according to claim 14, wherein the
2 uncoverable elements comprise one or more elements chosen
3 from a group of elements comprising uncoverable
4 statements, uncoverable states, unattainable transitions,
5 unattainable variable values, and unreachable conditions.

1 16. A method according to claim 1, wherein
2 formulating the respective coverability tasks for the
3 dominating blocks of the SUT comprises:

4 identifying a coverage model for the SUT;

5 defining a coverability model for the SUT responsive
6 to the coverage model; and

7 generating the respective coverability tasks
8 responsive to the coverability model.

1 17. A method for performing coverability analysis
2 in software, comprising:

3 formulating first and second coverability tasks for
4 software under test (SUT);

5 generating a rule regarding behavior of the SUT
6 corresponding to the first coverability task;

7 running a symbolic model checker comprising an
8 inflator to test a behavioral model of the SUT responsive
9 to the rule so as to produce an inflated result; and

10 evaluating the second coverability task responsive
11 to the inflated result.

1 18. A method according to claim 17, wherein
2 formulating the second coverability task comprises
3 choosing a plurality of coverability tasks from a set of

all coverability tasks for the SUT, and wherein evaluating the second coverability task comprises evaluating the plurality.

19. A method according to claim 17, wherein generating the rule regarding behavior of the SUT comprises:

performing a static analysis of the SUT comprising:
identifying a set of dominating blocks in the SUT;
and

solving a subset cover problem on the set of dominating blocks so as to produce a plurality of dominating blocks; and

selecting the first coverability task responsive to the plurality.

20. A method according to claim 19, wherein selecting the first coverability task comprises:

identifying a greatest-influence dominating block having a largest set of dominated blocks comprised in the plurality; and

selecting the first coverability task responsive to the greatest-influence dominating block.

21. A method according to claim 19, wherein the set of dominating blocks comprises a set of all dominating blocks in the SUT, and wherein the plurality of dominating blocks comprises fewer blocks than the number of all the dominating blocks.

22. A method according to claim 17, wherein running the symbolic model checker comprises performing a number of executions of the symbolic model checker, wherein the number of executions is smaller than a total number of coverability tasks for the SUT.

23. A method according to claim 17, and comprising writing the SUT in a programming language adapted to

define at least one of a group of elements comprising a software element and a hardware element.

24. A method according to claim 17, wherein formulating the first and second coverability tasks for the SUT comprises formulating the tasks by at least one of a group of methods comprising manual formulation and automatic formulation.

25. A method according to claim 17, wherein generating the rule regarding behavior of the SUT comprises generating the rule by at least one of a group of methods comprising manual generation and automatic generation.

26. A method according to claim 17, wherein running the symbolic model checker comprises evaluating the inflated result and determining the truth or falsity of the rule responsive to the evaluation.

27. A method according to claim 17, wherein generating the rule comprises instrumenting the SUT by adding one or more statements and one or more auxiliary variables thereto, so as to facilitate evaluation of the rule.

28. A method according to claim 27, wherein instrumenting the SUT comprises:

determining a plurality of basic blocks comprised in the SUT; and

for each basic block:

defining an auxiliary variable for the block;

initializing the auxiliary variable to zero; and

assigning the auxiliary variable a non-zero value upon execution of the basic block.

29. A method according to claim 27, wherein instrumenting the SUT comprises:

'3 determining a plurality of basic blocks comprised in
4 the SUT;

5 defining a single auxiliary variable for the SUT;
6 initializing the single auxiliary variable to zero;
7 and

8 assigning a unique non-zero value to the single
9 auxiliary variable upon execution of each basic block.

1 30. A method according to claim 17, wherein running
2 the symbolic model checker comprises producing the
3 inflated result regardless of the truth or falsity of the
4 rule.

1 31. A method according to claim 17, wherein
2 evaluating the second coverability task responsive to the
3 inflated result, comprises:

4 evaluating an attained coverability responsive to
5 the inflated result from running the symbolic model
6 checker;

7 evaluating an unattained coverability responsive to
8 the respective results produced by running the symbolic
9 model checker;

10 comparing the attained coverability with a plurality
11 of all coverability tasks for the SUT;

12 calculating a coverability metric responsive to the
13 comparison; and

14 analyzing the behavioral model of the SUT with
15 respect to the unattained coverability.

1 32. A method according to claim 31, and comprising
2 analyzing a design of the SUT, responsive to the
3 coverability metric, for at least one of a group of
4 properties comprising dead code, unattainable states,
5 uncoverable statements, uncoverable states, unattainable
6 transitions, unattainable variable values, and
7 unreachable conditions.

1 33. A method according to claim 31, and comprising
2 applying a testing strategy chosen from one of a group of
3 strategies comprising excluding uncoverable elements from
4 coverage measurements, setting coverage goals responsive
5 to the coverability metric, and determining a criterion
6 for stopping testing responsive to the coverability
7 metric.

1 34. A method according to claim 33, wherein the
2 uncoverable elements comprise one or more elements chosen
3 from a group of elements comprising uncoverable
4 statements, uncoverable states, unattainable transitions,
5 unattainable variable values, and unreachable conditions.

1 35. A method according to claim 17, wherein running
2 the symbolic model checker comprises:

3 performing a plurality of executions of an inflator
4 program so as to produce a plurality of inflated results;
5 and

6 evaluating the second coverability task responsive
7 to the plurality of inflated results.

1 36. A method according to claim 17, wherein
2 formulating the first and second coverability tasks for
3 the SUT comprises:

4 identifying a coverage model for the SUT;

5 defining a coverability model for the SUT responsive
6 to the coverage model; and

7 generating the first and second coverability tasks
8 responsive to the coverability model.

1 37. Apparatus for performing coverability analysis
2 in software, comprising a computing system which is
3 adapted to perform a static analysis of software under
4 test (SUT) so as to identify a plurality of dominating
5 blocks in the SUT, formulate respective coverability

6 tasks for the dominating blocks of the SUT, generate
7 rules regarding behavior of the SUT corresponding
8 respectively to the coverability tasks, run a symbolic
9 model checker to test a behavioral model of the SUT for
10 each of the rules so as to produce respective results for
11 the rules, and compute a coverability metric for the SUT
12 responsive to the results and the coverability tasks.

1 38. Apparatus for performing coverability analysis
2 in software, comprising a computer system which is
3 adapted to formulate first and second coverability tasks
4 for software under test (SUT), generate a rule regarding
5 behavior of the SUT corresponding to the first
6 coverability task, run a symbolic model checker
7 comprising an inflator to test a behavioral model of the
8 SUT responsive to the rule so as to produce an inflated
9 result, and evaluate the second coverability task
10 responsive to the inflated result.

1 39. A computer software product for performing
2 coverability analysis in software, comprising a
3 computer-readable medium having computer program
4 instructions recorded therein, which instructions, when
5 read by a computer, cause the computer to perform a
6 static analysis of software under test (SUT) so as to
7 identify a plurality of dominating blocks in the SUT,
8 formulate respective coverability tasks for the
9 dominating blocks in the SUT, generate rules regarding
10 behavior of the SUT corresponding respectively to the
11 coverability tasks, run a symbolic model checker to test
12 a behavioral model of the SUT for each rule so as to
13 produce respective results for the rules, and compute a
14 coverability metric responsive to the results and the
15 coverability tasks.

1 40. A computer software product for performing

2 coverability analysis in software, comprising a
3 computer-readable medium having computer program
4 instructions recorded therein, which instructions, when
5 read by a computer, cause the computer to formulate first
6 and second coverability tasks for software under test
7 (SUT), generate a rule regarding behavior of the SUT
8 corresponding to the first coverability task, run a
9 symbolic model checker comprising an inflator to test a
10 behavioral model of the SUT responsive to the rule so as
11 to produce an inflated result, and evaluate the second
12 coverability task responsive to the inflated result.

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